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Investigating the need for and interest in offering honey bee pollination services in apple production: Perspectives from growers and beekeepers in Midt-Telemark, Norway

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Abstract

Studies show that having an abundance of honey bees, *Apis mallifera,* can increase yield and quality in fruit production. Managed honey bee pollination services may be a contributing factor to agricultural productivity. Still, many crop producers utilize honey bee pollination services only to a small extent today. This master's thesis presents and discusses findings from in-depth interviews of apple growers and beekeepers on their perception about the need for and interest in offering managed honey bees for apple production in Midt-Telemark. Results showed that all growers value the benefits of honey bees, and several expressed a need to rent bee hives. The main reasons for this was to secure higher yield, better quality and more stable yields, especially in cold weather conditions in bloom. Despite appreciating honey bees' contribution, results also showed that several did not see a need to rent bee hives due to sufficient pollination from surrounding pollinators, both wild and managed, to achieve desired quality and yield. A few growers also raised concerns that honey bee abundance could increase costs due to increased thinning work. Most beekeepers expressed an interest in offering honey bee pollination services, primarily because they want the additional income. The partnerships can also provide a location to place hives as well as lead to growth in their bee colonies. This thesis also presents and discusses suggested actions from participants on how to improve the current pollination services business and its organization. Participants suggest more collaboration within the farming community to bring more attention to the issue and to increase knowledge and information on apple pollination, as well as to implement more effective distribution of the services and agree on practices to minimize potential dangers to honey bee populations.

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1. Introduction

Many aspects of today's food system will have to change in order to increase global food production and ensure continuous food availability for the world's increasing population (McKenzie & Williams, 2015; Rahman, 2016). Research indicates a rising demand for edible crop production (Ray, Mueller, West, & Foley, 2013). It is believed that this will contribute to a growth in sustainable agricultural, a reduced climate footprint from food systems, and a healthier human diet (Dwivedi et al., 2017; Willett et al., 2019).

Ecosystem services are defined as "the direct and indirect contributions of ecosystems to human well-being" (Kumar, 2010, p. 25). Animal pollination is one of the most important ecosystem services, as it helps increase and regulate crop production (Potts, Imperatriz-Fonseca, et al., 2016). Pollination, as an ecosystem service, has further been categorized as a part of our regulating services, defined as "the benefits obtained from the regulation of ecosystem processes" (Dıaz et al., 2005, p. 300). Pollination is ecologically, economically, and socially important. As other ecosystem services, it provides many benefits for humans (e.g. medicine, biofuel, wood, fresh water and fiber), and it helps maintain wild plant communities and ensure efficient agriculture – both in terms of yield and quality (Foley et al., 2005; Institute for European Environmental Policy, 2017; Norwegian Ministries, 2018; Potts, Imperatriz-Fonseca, et al., 2016). As pollination is important for agriculture, a diverse range of pollinators contribute to global food security, food diversity, and human nutrition (Ahlawat & Kumar, 2017). Animal pollinators are said to contribute to two-thirds of the world´s crop production and the production of 87 of all major food crops (A.-M. Klein et al., 2007; FAO, 2018). The economic value of insect pollination for the world agriculture is estimated to be at least 150 billion Euro (Gallai, Salles, Settele, & Vaissière, 2009).

The most effective and specialized pollinating insects are the bees, *Apidae*, (Breeze, Bailey, Balcombe, & Potts, 2011). Wild bee species are invaluable in their benefit to nature and food production (J. B. Free, 1993; Garibaldi et al., 2014; Garibaldi et al., 2016), but managed bees — especially the domesticated European honey bee, *Apis mellifera*, the most common managed pollinator in Europe — also play a significant role for the production of several nutritious and important food crops in many countries (A.-M. Klein et al., 2007; Potts,

Imperatriz-Fonseca, et al., 2016). Bees collect protein-rich pollen and nectar from preferred nutritious plants and transfer pollen grains on their bodies from one plant to another when it is in bloom (Norwegian Ministries, 2018). This pollination enables fertilization, reproduction, and the development of fruits and seeds (Ødegaard, 2014). The interaction between insects and plants results in both parties benefiting from the process; the plants have their genes distributed, and the insects are rewarded with nectar and pollen (Kearns & Inouye, 1997). If pollination in fruit production is not sufficient, it will decrease yield and quality (Delaplane, Mayer, & Mayer, 2000; A.-M. Klein et al., 2007; Potts, Imperatriz-Fonseca, et al., 2016; Samnegård, Hambäck, & Smith, 2019; Åström et al., 2014).

Managed bees can provide pollination for fruit growers in a flexible and effective way. The bee hives can be moved and placed in a controlled manner during the blooming season, and honey bees are versatile and forage on a range of species, but also restrict themselves to certain flower species, such as apple flowers (Delaplane et al., 2000; J. Free, 1963; Waser & Ollerton, 2006; Åström et al., 2014; Norwegian Ministries, 2018). Honey bees may also start their pollinating activity earlier than many wild pollinators and with a larger bee colony (Garibaldi et al., 2013; Norwegian Beekeeping Association, 2013; Åström et al., 2014). However, some scholars argue that managed honey bees do not contribute to improved crop yield and quality of fruit sets as efficiently as first thought, compared to wild pollinators, but emphasize the importance of pollinator diversity (Breeze et al., 2011; Fløystad, 2018; Garibaldi et al., 2014; Garibaldi et al., 2013).

It is hard to measure exactly how managed honey bees influence crop yields and quality. This is because abiotic factors (e.g., temperature, precipitation, landscape, growers' practices) also influence the produce (A.-M. Klein et al., 2007; A. M. Klein, Hendrix, Clough, Scofield, & Kremen, 2015; Norges Landbruksrådgivning (NLR), 2017; O. Lundin, Smith, Rundlof, & Bommarco, 2013; Vicens & Bosch, 2000). However, research indicates that having many honey bee hives close to a fruit production, preferably together with wild and diverse pollinators, results in a higher abundance of honey bees in the orchard, which has a positive effect on yield and quality of fruit sets (Brittain, Williams, Kremen, & Klein, 2013; M. P. Garratt et al., 2014; Geslin et al., 2017; Stern, Eisikowitch, & Dag, 2001; Åström et al., 2014). In the western part of Norway yields from fruit orchards (apple, pear and plum) showed a

production increase of 15-30% when bee hives where introduced, which gives an annual value of more than 10 million NOK (Grofondet, 2019; Norwegian Beekeeping Association, 2020)[1].

The importance of insect pollinators has been receiving increasing attention for the last decade, for a variety of reasons. Studies show a disturbing global decline in wild pollinator species and a high mortality rate for managed honey bees, as well as a decline in the number of beekeepers; this has been seen especially in the United States and parts of Europe (Council, 2007; Ghazoul, 2005; Paudel, Mackereth, Hanley, & Qin, 2015; Potts, Roberts, et al., 2010; Winfree, Aguilar, Vázquez, LeBuhn, & Aizen, 2009). This trend is most often attributed to human disturbance of the environment. It is evident that the functioning of ecosystems, as well as levels of biodiversity and pollinator populations, are being threatened by land use changes, habitat loss, and intensified agricultural practices, including the widespread practice of monoculture and extensive use of agrochemicals (Kremen, Williams, & Thorp, 2002; Potts, Biesmeijer, et al., 2010; Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies, 2005).

Nonetheless, as the number of pollinators has declined, there has been an increase in insect-dependent crop productions, which has led to a demand for more pollination services at the commercial level (Aizen, Garibaldi, Cunningham, & Klein, 2008; Aizen & Harder, 2009; Potts, Ngo, et al., 2016). In some countries, pollination services are already a big business and organized professionally, such as in the United States (Burgett, Daberkow, Rucker, & Thurman, 2010). This is due primarily to their high level of monocultures. On the other hand, a study surveying ten European countries showed that less than a third used managed pollinators for crop pollination (Breeze et al., 2019). Therefore, there may be a lot of room for growth in Europe regarding pollination services at the commercial level.

The decline in pollinators and increase in pollinator-dependent crop production, calls for increasing attention on new farming methods and sustainable agricultural intensification (Kleijn et al., 2019; Kovács-Hostyánszki et al., 2017). One of the targets presented in the

1 Grofondet is a Norwegian funding institution aiming for growth in Norwegian crop production. Together with the Norwegian Beekeeping Association, Grofondet contributes to the project PolliVest. PolliVest was a research project conducted in the Western part of Norway. The goal was to increase the use of honey bee pollination in fruit and berry production, and, resulting from this project, they have seen an increase in yield.

Sustainable Development Goals, SDG 2, highlights the need for developing sustainable food production systems; this includes developing sustainable agricultural practices that will increase productivity (United Nations, 2019). It is vital to start producing more food on existing land with less and better inputs. Attention on ecological intensification to sustainably increase crop production and meet the growing demand for food worldwide creates a need for growers and others in the sector to understand how ecological functions, such as pollination, influence yield (Bommarco, Kleijn, & Potts, 2013). Therefore, insight into the main stakeholders´ (growers and beekeepers) understanding and experiences on insect pollination in crop production, and whether growers perceive a need for honey bee pollination services and if so how they should be organized, is needed in order to design measures for how honey bees can contribute to more productive and sustainable agriculture. Investigating stakeholders´ perceptions may also identify possible knowledge gaps.

Norway is an example of a country having a national goal to increase production and consumption of domestically grown fruits, berries and vegetable products (Korsæth & Geipel, 2016; Norwegian Institute of Bioeconomy Research (NIBIO), 2016; Svennerud, 2004). Apples, *Malus Domestica,* are one of the important fruits to which the Norwegian agricultural sector is giving its support and attention through multiple development projects. More recently, investments have been made among growers to increase apple production and, on a national level, to modernize and incorporate new technology. The trend in recent years shows a structural change in the Norwegian agricultural sector towards more large-scale production (Bjørlo & Rognstad, 2019). Some researchers claim that pollination support from managed bees may be even more important in large-scale productions to ensure optimal yield and quality (Isaacs & Kirk, 2010; Levin & Waller, 1989). Apples require cross-pollination and pollen from a genetically different compatible individual; this cross-pollination happens as a result of insect pollination and is necessary in order to set fruit (Kendall, 1973). Achieving required first-class quality[2] is very important for fruit producers in order to get access to and distribute their products on the national markets and receive the highest sales price as possible. Domestic fruit production can have tough competition from trade with international markets, despite seasonal import protection.

2 Norwegian system for quality classification of fruit and vegetables. First class (class 1) quality, is required for the grower to receive the highest price for their products.

Today, over 4000 beekeepers are registered as members in the Norwegian Beekeepers Association (NBA). They are from all over the country, rural as well as urban areas. Interest in beekeeping is on the rise, and there is also a growing demand for Norwegian honey (Norwegian Ministries, 2018). More precisely, the NBA has almost doubled its number of beekeepers in the last decade (Haraldsen, 2017). However, beekeeping in Norway is mostly done as a business for honey production, and the majority are hobbyists (Ministry of Agriculture and Food, 2016). Pollination services as a business, with beekeepers actively renting out their hives to growers, are so far offered only to a small extent. Still, the value of the contribution from pollination services of managed honey bees are estimated to be 150 million NOK annually (ibid.). Today, Norwegian fruit growers hire bees from pollination services to a varying degree. In 2016, less than 50% of apple and plum growers used honey bees in their orchards in two of the main fruit producing areas in western Norway (Grofondet, 2019).

In this study, the objective was to investigate apple growers´ and beekeepers´ experiences and perceptions about the need for and interest in offering managed honey bees for apple pollination. This was done to understand whether pollination services can potentially be used as an input factor to a greater extent to improve productivity. I also wanted to investigate participants´ perceptions on how the pollination services business could potentially be improved and better organized. This was done by interviewing selected representatives of these two stakeholder groups in Midt-Telemark, a district in Vestfold and Telemark county, which has become one of the largest areas for apple production in Norway and where the beekeeping and pollination service businesses is on the rise. The interviews were guided by the following research questions:

I. Do apple growers see a need to rent managed honey bees from beekeepers to support pollination services or not, and for which reasons?
II. Are beekeepers interested in offering pollination services by placing bee hives close to apple orchards, why or why not?
III. What actions do apple growers and beekeepers think should be taken to improve the current offering of pollination services?

2. Material and Methods

Study Area

I selected the district Midt-Telemark as my study area because it is an important area for apple production in Norway. The district includes the municipalities Midt-Telemark and Nome, located in Vestfold and Telemark county (see map in figure 1). Vestfold and Telemark is the second largest fruit-producing county in Norway after Vestland (Mæhlum, 2019). Many of the largest areas for fruit production in the county are in Midt-Telemark district. For my research, I investigated apple growers and beekeepers from the areas Sauharad, Nome, Ulefoss, Svenseid, Bø, Akkerhaugen, Nordagutu and Gvarv, also known as Fruktbygda.[3]

Recently, large investments have been made to increase the production volume in the area. Many new apple fields were established between the years of 2016 and 2018, and the production volume is expected to increase by 20-30% within the next three to four years (personal conversation, Bjørg Hestag/ manager at Telefrukt AS[4], 04.03.20). The majority of apple growers in the region are connected to Telefrukt. Today, Telefrukt has a total of 75 members who are fruit producers in the Telemark region and among these, 60 are growing apples in Midt-Telemark district (ibid.).

The Beekeeper´s Association in Midt-Telemark currently has 60 members, and many beekeepers are placing hives throughout in the local fruit and natural landscape. The number of beekeepers has increased in recent years, but only a handful are considered active beekeepers having it as their main or partial occupation (personal conversation, Johannes Berget/ spokesman for NBA Midt-Telemark, 03.02.20). Only a few of the beekeepers located in Midt-Telemark district are renting out bee hives for pollination services.

3 Meaning “fruit valley”.

4 Telefrukt AS, located in Midt-Telemark, is the biggest fruit packer in Norway. They pack, process and distribute apples, plums and cherries from producers in the Telemark region and parts of Vestfold and Viken (in total 90 members), to the biggest supply chains in Norway (Rema 1000, Norgesgruppen and Coop). Telefrukt is owned by their members (45%), BAMA (45%) and Gartnerhallen (10%). Telefrukt has recently invested in storage technology (Ultra Low Oxygen Storage, ULO) and modern machinery to meet the increased production level and to extend the period of availability for Norwegian fruit. From the 1st of November, 2020 all fruit will be stored in ULO-storage. Source: www.telefrukt.no

The growing conditions in Midt-Telemark are very favorable for fruit production due to its suitable climate, the topography of the area, and the quality and properties of the soil (NIBIO, 2020). The weather and temperatures are more stable compared to the coastal areas where fruits are grown, especially in western Norway, and the summer temperatures are relatively warm (Lundbo, 2018). This creates good conditions for both apple production and beekeeping. Figure 1 shows a map of the area studied and the participants' location. However, beekeepers move their apiaries around in the district – either close to farms and orchards or near gardens and other wooded areas, depending on the management and whether they hire out hives to apple growers or not – to find locations with good nectar supply for their honeybees.

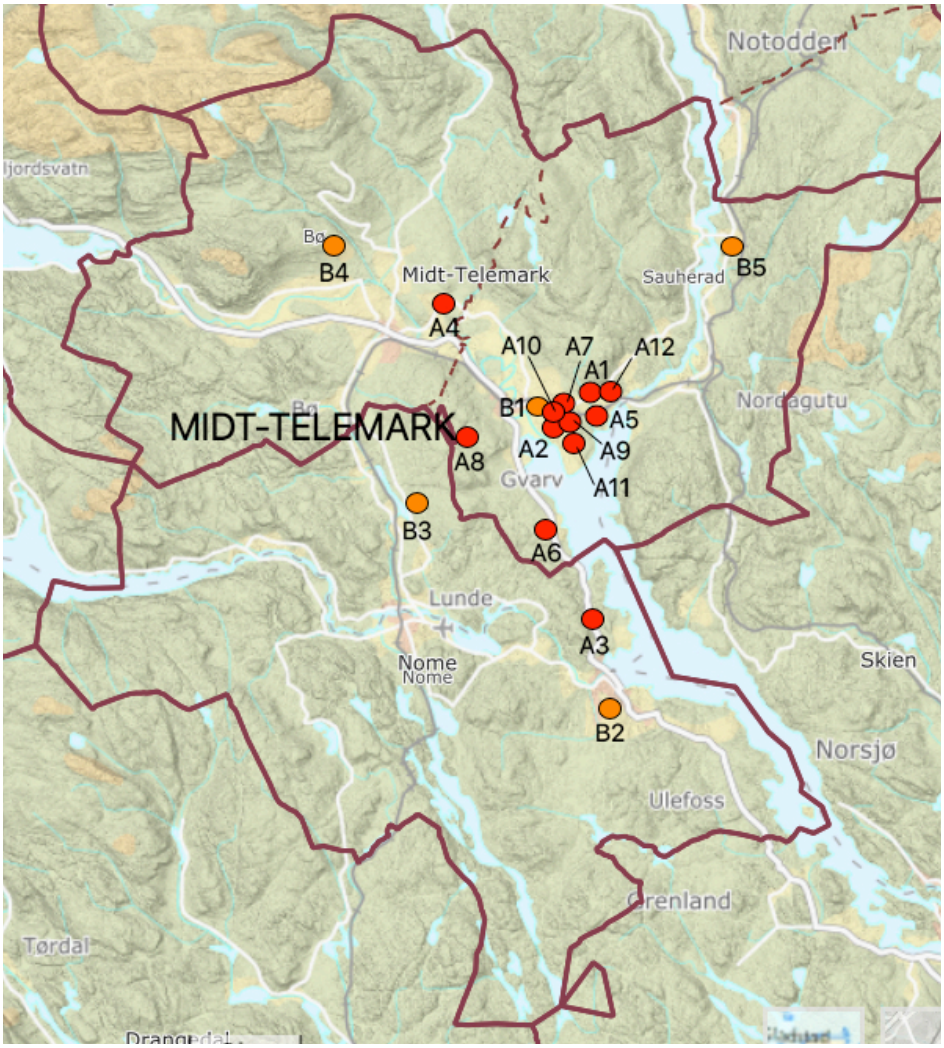

Figure 1. Map of Midt-Telemark district. The district includes both Midt-Telemark municipality in the north and Nome municipality in the south. Orange and red points illustrate beekeepers (B1-B5) and apple growers (A1-A12) visited. Source: Norgeskart.no

Methods

I chose a qualitative research method to answer the research questions in order to get information from the participants about the topic in their own words (Bryman, 2012). I conducted semi-structured in-depth interviews with 17 participants, and of these, five are beekeepers and twelve are apple growers in the Midt-Telemark district.

All apple growers interviewed in this study are members of and deliver their apples to Telefrukt. They are also a part of the Norwegian farming extension services (Norsk Landbruksrådgivning, NLR)[5]. For the present study, I reached the most active apple growers and beekeepers in the district. The most active growers, according to Telefrukt, are the growers who have largest apple areas (measured in hectares) and/or deliver highest apple volume (measured in tons) to Telefrukt. The twelve apple growers selected for this study grow apples as their primary crop. The most active beekeepers are the ones who are most engaged in renting out hives in the community and are among those with the largest number of hives. All the beekeepers in this study produce honey and operate on a level that can be considered as a business and not a hobby (defined here to be over 25 honey bee colonies).[6] While the extent to which beekeepers rent out hives to apple productions may vary, they all have some experiences and knowledge about pollination services in the district.

Prior to the interview process, a test interview was conducted with an external professional beekeeper. The interviews were conducted in two rounds. First, 10 of the interviews were carried out during two days at the end of January 2020. These were face-to-face interviews that took place when I visited the participants either at their home or at their workplace. For the second round, I conducted seven phone interviews during three days in the end of March 2020. All interviews had a duration of 45 minutes to one hour and was following a flexible interview guide (Bryman, 2012) (see appendix A and B). The interview guide was based on my main topics but was open for interviewees to bring up new topics relevant for this study. One interview guide was adopted for the apple growers and another for the beekeepers. Sixteen

5 The local NLR (NLR Østafjells) covers growers from Vestfold and Telemark, and some areas in Viken.
6 In this study, beekeeping is considered as a business, as opposed to a hobby, when beekeepers have over 25 honey bee hives. In general, then, they will generate a revenue (from honey production, depending on the market price of honey) at a level where you will have to register in the tax system and can therefore receive production subsidies (Fløystad, 2018).

of the 17 interviews were done with audio recordings, for those who consented. A consent form and a project description were given to all interviewees prior to the interview. All recordings, in addition to my own notes from each interview, were later transcribed.

Interviewees were selected by purposive sampling (Bernard, 2017). In order to map actors in the district and select participants for my study, I contacted the local NLR, the local NBA and Telefrukt for information about relevant persons to contact for my research. This was done in combination with a snowballing technique (ibid.), where I contacted apple growers and beekeepers with a request to participate in my study as well as for any further recommendations of relevant people to contact.

Data Analysis

The transcribed data collected were analyzed with guidance from Graneheim & Lundman´s method of content analysis (2004). As the first step of the analysis process, I read through each of the transcripts to get a general overview of the content. I identified some preliminary themes, *content areas*, from the data material. I had also taken reflection notes during the interview process and some content areas could be identified already at this stage from these notes. In the next step, I extracted the text from the interview transcripts and sorted by content area, which formed the *units of analysis*. Important and relevant text from the different units were then broken down into *meaning units*, and then broken down further into *condensed meaning units.* Next, I labelled the condensed meaning units with a code describing the essence of that specific text (see example in table 1). Finally, related codes were gathered and placed into 12 sub-categories, which again resulted in five main categories (see table 2).

I separately analyzed the apple grower and beekeeper data, but I used the same technique as described above, to condense the information, for both. Some content areas were revealed to be applicable to both groups. To create an overview of the data analysis, I used an Excel spreadsheet. I conducted and transcribed the interviews in Norwegian, but relevant text and quotes in the present study I translated into English.

Meaning unit	Condensed meaning unit	Code	Sub-category	Category
I believe it has made a great difference. The harvest increased significantly	Honey bees made a difference and increased yield	Increased yield with honey bees	Bee hives improve apple yield and quality	Reasons for renting honey bee hives
Over the years, I have noticed that my harvest got more stable after I got bee hives	Noticed more stable yields over the years with bees	Honey bees gave more stable yields		
In general, pollination is important to get a crop but also to get the correct shape and obtain stable harvests	Honey bees important for correct shape and stable yield	Better and stable harvest		
Logical to think that way, that good pollination will improve the overall quality of the fruit. So when it is harvested at the right time, you will get an apple with good storage capability	Good pollination, you may get an apple with good storage capability	Well-pollinated apple are linked to storage capability		
I would not have been without. It serves as an extra security	I would not have been without. It serves as an extra security	It serve as an extra security	Honey bees serve as a pollination security	
If you have a year with good weather in bloom, you may be fine without honey bees, but you do not know that	When good weather you may not need bees, but do not know that	Extra security in in bad weather		
In seasons when the weather is colder in bloom then it is extremely important to have bees in the orchard	Extremely important with bees when whether is cold	Important with bees when whether is cold		

Table 1: Example of analysis from meaning unit, to condensed meaning unit, codes and how I organized it into sub-categories and categories.

Category	Sub-category
Reasons for renting honey bee hives	• Bee hives improve apple yield and quality • Honey bees serve as a pollination security
Reasons why some growers do not rent honey bee hives	• Already achieving desired yield and quality without bee hives • Uncertainty and lack of documentation about the need for honey bees • Abundance of pollinators may require extensive thinning work
Benefits for beekeepers in doing pollination services	• A place to station apiaries and build strong bee colonies • Pollination service business provides additional income • Desire to contribute to agricultural productions
Challenges in today´s pollination services business	• Lack of organization • Concerns about growers´ field practices
Areas for improvement and suggested actions	• Increase attention, information and knowledge on insect pollination in fruit production • Increase collaboration between actors to improve organization

Table 2: The 12 sub-categories organized into five categories.

Presentation Of Participants

All the apple growers who participated in this study have recently or are currently establishing new apples fields. Most of them have invested in modern apple production systems, including harvesting equipment, machinery, and specific field layouts, which include pollinizer trees. They establish apple varieties that are suitable to markets, more resistant to pests and disease as well as better adapted for storage, e.g., Rubinstep. However, whether growers are using rented bee hives for their production varies. All the growers practice a conventional production method. Some of them have additional cultures such as cherries, plums, black currant, strawberries, or grains, and some engage in testing of new pear varieties. Most growers are doing the majority of tasks on the farm themselves but hire a workforce in the labor-intensive season. A few growers have external occupations besides producing apples and are then hiring more labor for doing farm operations. A few of the growers have additional fields, besides their own farmland on which they also produce apples. These are

apple fields leased from other landowners or run in collaboration with other apple growers. See table 3 for basic information about the apple growers and their production.

Apple grower no.	Location	Area apples (ha)	Bee hives in field	Rent hives	Experience (years)	Age	Gender
1	Akkerhaugen	5.4	0	No	10	50	Male
2	Gvarv	11	12- 15	Yes	21	53	Male
3	Ulefoss	2.8 himself, +5 w/ others	3	Yes	13	38	Male
4	Bø	5.5	10-15	No, but plan to	6	39	Male
5	Akkerhaugen	27	0	No, but wants to	25	52	Male
6	Gvarv	6	15-20	No	28	59	Male
7	Gvarv	7.8	0	No, but wants to	7	37	Male
8	Nome/Gvarv	3.5, 50% leased area	0	No	1, new grower	37	Male
9	Gvarv	8 himself, +10 leasing	0	No	28	47	Male
10	Gvarv	3.5 + 1.2 next year	0	No	23	50	Male
11	Gvarv	9.5	0	No	27	47	Male
12	Akkerhaugen	7	40-50	No	37	56	Male

Table 3: Information about apple growers.

The beekeepers in this study currently provide pollination service to different extents. The beekeepers are not only renting hives to apple growers, but also to producers of other cultures such as cherries, raspberries or other tunnel productions. A few of the beekeepers are full time beekeepers, while the other three of the beekeepers have another main job, either as growers (cherry and raspberry) or within other professions. See table 4 for basic information about the beekeepers.

Beekeeper no.	Location	Business or hobby	No. of hives	Rents out hives	Years of Experience	Age	Gender
1	Sauherad	Second job, raspberry farmer	105	Places for free in apple orchards (20 hives in tunnels)	40	58	Male
2	Nome	Second job, not a farmer	75	25 hives to apple growers	15	41	Female
3	Svenseid	Full time	300	98 hives to 10 growers (who rent from 4-18 hives)	40	55	Male
4	Bø	Second job, cherry farmer	72	10 hives to one grower (use 50 hives in own production)	26	47	Male
5	Nordagutu	Full time	277	0	20	65	Male

Table 4: Information about the beekeepers.

The skewed gender balance in the study is primarily due to the fact that men dominate the target professions. This is particularly true among apple growers. Several of the apple growers run their farms in part as a family business; however, at all the farms where I did interviews, men were the managers of the business. Among the beekeepers I was able to interview, only one is a woman.

Since both the apple growers and beekeepers are located in the Midt-Telemark district, they are engaged in the same farming community, and many are familiar with each other's operations and productions. Some of the beekeepers in the study place their hives in the participating apple growers´ orchards.

Most of the participants in the study are part of a generational line of apple growers or beekeepers. Most apple growers have agricultural education or have acquired knowledge on apple production from participating in seminars and courses, in addition to support provided by NLR. However, most growers who do not have an agricultural education have degrees in other fields, such as engineering, business, or economics.

3. Results

Reasons for Renting Honey Bee Hives

Bee hives Improve Apple Yield and Quality

The primary goal of the apple growers interviewed for this study is to produce first-class apples with the right quality, and to get high and stable yields for the lowest possible costs. In the interviews, all growers acknowledged that they are dependent on pollination to achieve this. Accordingly, they agreed having bee hives close to orchards tends to increase apple quality and yield, but it varied as to whether they believe it is necessary to have bee hives in their own field to achieve this.

Several growers experienced increased yield after having bee hives close to their apple fields, with a noticeable difference in production as compared to years without. Apple grower number 2 (A2, see table 2 and 3 in chapter 2 for information about the participants) explained: "I have rented bee hives for many years. My dad, who ran the production before me, did not. I believe it has made a great difference. The harvest increased significantly. Even on the old trees I had back then" (A2). Using pollination services is seen by this participant as one of the top priorities when blooming season starts. However, for newly established fields, he believes it can be favorable to delay installing pollination hives until the trees are two to three years so that the trees can first use their energy to grow strong. Another participant also explained that using bee hives on his farm was not traditional, but he wanted to give it a try to see if it affected his yield; after renting a few bee hives and placing them in the orchards the production increased. The grower noticed more fruit set on each tree and was able to deliver more apples (A3). After this experience, he now thinks it is crucial to have bee hives nearby apple orchards.

Attaining stable yields is one of the most significant and challenging tasks faced by apple growers, and, according to these growers' experiences, pollination services close to orchards can help a great deal. Several apple growers explained that yields can vary significantly from one year to the next, depending on varieties, agronomic practices and weather conditions. One grower, who has been using many (approximately 30-40) bee hives the last 10 years,

explained: “Over the years, I have noticed that my harvest got more stable after I got bee hives. I no longer have the really high or the really low seasons. It is more stable. And that is what we want. (...) When you get the stable yields, then you succeed as a fruit grower” (A12). In addition to stability, he has seen a growth in apple yield and fruit set. Similarly, another advantage the bees provide production is proper fruit shape. One farmer described: “In general, pollination is important to get a crop but also to get the correct shape and obtain stable harvests” (A6). Some of the growers also reflected on how honey bee pollination can influence production: “An interesting case, before, there was little beekeeping here, but a swarm once settled and stayed in my garden. I got good crops every year after. Whether it had anything to do with the bees or was a coincidence, or if there were other things influencing it, I do not know. But there was a noticeable difference form one year to the next” (A9).

Many of the growers who experienced an increase in yield are also seeing honey bees have a notable effect on fruit quality. One grower expressed his enthusiasm that he now achieves better quality and gets higher yield every year from his apple production (A3). Some of the growers test whether pollination has been optimal by cutting the apple in half and looking for a symmetric development of the seeds in the core. One said: “If there are fewer or missing seeds, it is a sign of poor pollination. You can see it in the unripe fruit. I often wear a knife and slice or split the fruit” (A2).

According to a few of the apple growers, ensuring sufficient pollination can improve the capacity of the apples to retain their quality in long-term storage and be more resistant to damage, which can be caused by pressure. However, one participant expressed an uncertainty about whether this has been formally studied, saying this perception is rather based on his own assumptions and from what he has heard in the farming community (A9). He also said that he did not have optimal pollination the last two years because of some cold periods in the spring, and he could tell because there were less seeds in the core. He further explained that he could have used honey bees for better pollination. However, he was still able to deliver first-class apples since Norwegian apples are normally consumed within a short period of time. He believes that the situation would have been different if the apples were going to be stored over a longer time. He believes pollination can be even more important for

apple quality now, as Telefrukt introduces long-term storage in order to market Norwegian apples until December. Another participant shared his belief that pollination can maintain quality in long-term storage but felt uncertain about the exact mechanisms. He said: "I think it may have something to do with cell division without me being an expert in that field. It is kind of logical to think that way, that good pollination will improve the overall quality of the fruit. So when it is harvested at the right time, you will get an apple with good storage capability" (A12).

Several participants shared the impression that most growers who start to use bee hives do not stop but consider it as an important factor for production. However, several apple growers also expressed the importance of looking at the effect of honey bees in combination with other factors. Several participants specified that favorable weather conditions as well as more intensive use of fertilizers and new fertilizer methods, in combination with more honey bees, also play a role in years with good harvest results. One apple grower explained it in this way: "Fertilizer makes the tree bloom more, then you need the bees to pollinate the flowers. Otherwise, the fertilization will be wasted if you do not have the bees and insects to do the job. They [bees] become a part of the total package. It is difficult to say exactly what percentage the one or the other contributes to production, but I am sure they [honey bees] have a significant effect" (A3).

Honey Bees Serve as a Pollination Security

Several participants explained that bee hives in the field act as an extra security measure in seasons with unfavorable conditions. Most growers agreed that honey bees are most useful when weather conditions are unstable and temperatures are low during the spring bloom. Several growers stated that honey bee colonies are ready to pollinate quickly and effectively when temperatures rise and weather improves. One participant explained: "You need the hives when you have a bad year. I mean, you need it when you need it. Suddenly you have a bad year and then you need it a lot. If you have a good year when it comes to pollination you might not notice any difference. But in general, you will have a good use of it. I would not have been without. It serves as an extra security" (A6). Other participants agreed with this understanding, and shared the same experience: "If you have a year with good weather in

bloom, you may be fine without honey bees, but you do not know that. Instead, I try to regulate the level of fruit set in other ways which is easier to control, for instance by more thinning. You need to thin trees anyway, on most varieties" (A2). Another grower explained that he noticed significantly less bees out one season in the cold periods, which can impact fruit quality and cause damage and problems from weather, wind and hail later on (A7). A third apple grower explained that the bees do not fly far when the weather is cold but stay closer to the hives, which is very important for the apple pollination (A12). He further said: "I have had bee hives the last 10 years. Before that I did not have any, but my neighbors had a few, which was too little. And as I said, in seasons when the weather is colder in bloom then it is extremely important to have bees in the orchard."

Some growers explained that even if there is a risk that having additional bees would not be necessary if weather conditions are good, it is a small investment to make to control and ensure pollination. One of the largest apple growers pointed out the importance of doing whatever he can to eliminate everything that could possibly go wrong, and said that he could not necessarily think about the effect he can get from having honey bees. He explained: "I do not dare to say *how* important the effects from honey bees are compared to other inputs in my production, but for me personally, it is important to make sure that things do not go wrong. And that is why I see the need for having bees at my farm" (A5). He made further comparison to other factors. For example, he minimizes the risk of drought by installing drip irrigation; also, he makes sure to follow a number of different good fertilizer practices even though they may not be necessary that year. He explained that doing this gives him inner peace; he does not want the uncertainty to keep him awake at night. It is the same with bees. It is important to mention that this grower has not had bee hives on his farm since he quit beekeeping himself seven years ago. However, the last two years he has tried to find bee hives to rent, without success. Despite not having honey bees on his farm, he confirms an increase in yield. He recognized that lack of pollination has not been a problem and so he has given other factors, besides procuring bee hives, a higher priority. Several other growers shared this regard for input prioritization. However, the bottom line he describes for facilitating honey bee pollination is about safety, and he emphasized his goal: "You do measures that in the big picture contribute to good and safe production" (A5).

Some growers also pointed out another interesting issue: the differences between wild pollinators and managed honey bees in their orchards. Many of the apple growers observe and hear buzzing of bumble bees and other wild pollinators in their apple fields when spring has been warm and sunny. One of the growers who has bee hives close to his farm said: “It is a lot of bumble bees and wild bees pollinating here too. I try to be aware of pollinators, but it is difficult to know whether you are well covered with pollinators in the area. It is difficult to know where they come from; if they are native pollinators, or if they come from the hives down here. It is hard for me to quantify” (A4).

Some growers have noticed a decline in wild pollinators in their fields over the years. There are especially less bumble bees observed in early May. “It seems like it has changed, even though I have not done any study. I absolutely believe it is necessary to add managed bee hives,” one grower said (A2). He described that the weather conditions affect when native pollinators will be active and how many you will find in the apple field. The same participant said: “If the weather has been warm the weeks before bloom there are much more wild bees out to observe. If it has been cold, then there are not. The weather has a big effect.” Another apple grower stated: “There are a lot of bumble bees to observe when I walk in the apple fields during bloom, but I would not be successful without honey bees. (…) No matter how bad weather has been, if you then get a few hours with sun, being in the field would be like putting your head in a bee hive. The honey bees will be out in the field. Wild pollinators will be scarce” (A6). The grower who uses a few hives in his apple orchard observed more activity and buzzing in the field and a significant increase in number of bees when putting bee hives into his orchard: “You would hear it. It is a lot more activity in the field now than before the bees came here” (A3).

Another interesting finding from my study is that several participants have noticed a slight change in climate over the years. The most common perceptions pointed out was that the season starts a bit earlier than it did before, even several years ago, sometimes varying by more than two weeks from year to year. They are also seeing more unstable weather. Some growers perceive honey bees as an important safety measure in these shifting weather conditions.

Several participants pointed out the importance of using honey bees in bigger apple productions, for added security, and ensuring adequate pollination. They believe that pollination services will be more important in the future as fruit productions in Midt-Telemark are growing, and that larger production areas will need even more effective pollination during bloom. One participant explained: "The apple production has had stable growth recent years, so the need for honey bees will increase if we continue to establish and plant new apple fields like we are doing now" (A3). Another grower explained that they have not been using bee hives themselves, but they plan to start renting honey bees as added security because they have established new apple fields and have increased their production drastically, nearly tripling production. He said that the need for bees have therefore increased accordingly (A7). This grower was in contact with a beekeeper for renting hives but did not rent any due to lack of a proper spot to place them.

Reasons Why Some Growers Do Not Rent Honey Bee Hives

Already Achieving Desired Yield and Quality Without Bee hives

Several growers expressed their satisfaction with present pollination conditions with respect to quality and yield in their apple production without added honey bee hives on their farm. Therefore, these apple growers have not considered renting hives as a part of their production practices. Some of the most active growers in this study did not use hives in their production but said they were satisfied with the current apple yield and results, and had also noticed an increase in yield in previous years (A1, A5). One of these growers, described by the community as one of the most successful and skilled in the district, explained that bees are an important part of the production process, but hard work and many other practices are also important to achieving those good yields (A1). Although the previous generation used bee hives at this farm, he has not felt the need to rent additional hives for apple production as he sees already many pollinators in his fields.

Several of the growers said that they choose not to rent hives at all because they perceive Midt-Telemark as already well covered by insects and pollinators. Further, they recognized that this is very much due to all the beekeepers who place their apiaries around the district.

Many growers said that they observe plenty of honey bee hives around their area; they observe bees in the field and do not notice any quality reductions that they believe are connected to poor pollination. Reduced quality could rather be linked to weather conditions such as frost, hail, other insects, or diseases (A7). However, some also pointed out that if these surrounding bee hives would not have been there, the yields would have been smaller.

The expression being a "freeloader"[7] is mentioned by several of the participants, including some beekeepers. This expression refers to growers who benefit and rely on apiaries nearby or from neighbors who have rented honey bee hives, instead of obtaining bee hives for themselves. Some participants explained that there are always some growers who rely on others to get pollination for free. Situations like this seemed to bother some beekeepers: "It annoys me sometimes that there are some stingy people who are not willing to pay for hives. They get it for free. Often, these might be the people walking around and saying that they do not need bee hives because there are enough in the area," the most active pollination beekeeper said (B5). One grower, who does not utilize bee hives, explained: "They [honey bees] have an effect for sure. Of course! We are dependent on bees for pollination. If I were located alone out there, I would have to make sure I had bee hives myself. (…) I would have noticed a difference without the bees" (A10). He also explained: "The bees fly a few kilometers around their hives, and we have some big beekeepers who have quite a few bee hives within that radius. That is very good. I am well covered today. So, I will not rent any hives if the situation stays the same." This same grower described that a beekeeper once placed hives for free at his farm some years ago, but he did not notice any effect on the production after the hives were removed. His impression was that most growers, which is many in his area, procure a few (two to four) hives and he believes that the hives placed close to his farm are sufficient. One of the smaller growers in this study explained that he had to try to limit his expenses as much as possible and would rather not pay for hives (A11). He explained that pollination works well for him if his neighbor procures hives, but if the neighbor did not have any hives, the grower would consider renting hives himself.

7 Meaning «gratispassasjer»

Another perspective, as explained by several growers, is that there has not been a strong tradition for renting honey bee hives in earlier generations. It has been a general impression that there are enough honey bees and other pollinating insects around to pollinate apple productions sufficiently. One grower, who just took over his farm from his father, described that he bases much of his decisions on the earlier generations´ evaluations and experiences, and for his case insufficient pollination has not been a problem. Some beekeepers also share this understanding of how traditions play a role in today's use of pollination services. One apple grower pointed out that the agricultural extension service, NLR, will play an important role in this context, because he thinks growers will listen to information provided from NLR. At the same time, he said that some growers from Telemark are known to do things in their own way (A6).

Some participants, including beekeepers, also described a laidback attitude towards pollination services among many apple growers, such as "it has been going well before, so it is probably going well now, too" and the "it will fix itself"- mentality. Participants believe this attitude stems from previous generations and traditional knowledge as well as growers´ more recent experiences. One grower explained that he used to share this perspective, but wanted to see if honey bees could increase his yield (A3). As explained previously, this grower noticed a significant rise in yield after employing bee hives. Notably, several growers have seen a change of attitude among the new generation. Growers are witnessing a slight generational shift in the apple grower community regarding attitudes towards the value of honey bees as an input factor. The reason for this, as supported by some participants, is connected to a stronger general emphasis from NLR, media and environmental trends.

Uncertainty and Lack of Documentation About the Need for Honey Bees

Another finding from my study on why some did not use pollination services in Midt-Telemark was that several apple growers are uncertain about the specific effect using more honey bees in field will give, and how it can improve their production, especially since these growers feel they can deliver high quality apples without employing additional bee hives.

There is consensus among growers that they know too little about the biological mechanisms connected to honey bee pollination in fruit production. Some growers explained that they observe buzzing in the garden but expressed an uncertainty about what type of pollinator species they have in the apple orchard. One grower did not dare to assert anything about the effect of honey bees, because he did not have enough expertise (A5). Another grower added: "Insect pollination is a part of the whole production which I do not know enough about as an input factor" (A1). A third grower who has bee hives on his farm explained that he believes it is very difficult to control all variables that affect pollination and, therefore, also challenging to measure and understand the effect of honey bees on production (A4).

There is also a lack of understanding around the effectiveness of bee pollination in cold temperatures. This was mentioned by one of the participants who did not rent hives. He said: "There has been more attention on the importance of honey bees, not only for fruit production, but in general. It is crucial! But I cannot tell you how important it is for apples. I guess it is important. (...) But the bees do not fly with a raincoat and an umbrella, so in bad weather it helps very little" (A1). Another grower explained that he had a difficult start one season with periods of cold weather in spring and explained: "It was very cold and there was not a bee in sight. I thought, what do I do now? How long will the flower live? It normally does not live long before it withers. (…) The situation did not look good. There were not many apples on that variety because of the frost, but whether it was mostly the frost or because of less visitation from bees, I am not sure. It is hard to measure and know exactly the reason" (A7).

Several growers expressed that there is little documentation on the effect and the importance of honey bees in apple production. One of the biggest growers, who wants to start renting bee hives, asked himself: "I do not have any documentation or clear evidence that my yield is less good because I do not have bees today. When I look at my results, they are increasing. But I will not put my head under the ground and distance myself from reality, because if you are growing apples and want high quality you are dependent on sufficient pollination, and then bees are important. But the question is: are additional honey bees necessary? That is always the question I ask myself for which I do not have a good answer" (A5).

Many growers are also uncertain about how many bee hives one should use in relation to production size. Most growers explained that this sort of information has been limited and out of date, so growers would either ask the beekeeper for advice or base the decision on their own assumptions. One participant explained: "It seems like the recommended number of hives are a little random and the same no matter the field size" (A5). However, most growers who used bee hives were satisfied with the number of bee hives they had even though the number varied significantly among growers. Some growers used 15-20 hives, while others considered five bee hives as enough to secure good pollination and apple quality. One beekeeper, who also produces cherries, expressed that there is no clear answer on how many hives to use: "The farmers do not know either. One year it is cold in the spring, another it is warm. One year there are many bumble bees, and another there are few. It varies and it is hard to know. (…) There is simply too little knowledge about this" (B5). Participants agreed that they would like to know more about honey bee pollination and its effect on fruit production, particularly in different weather conditions.

Abundance of Pollinators May Require Extensive Thinning Work

There were different perceptions among apple growers about how pollinator abundance can potentially result in too many fruits and, thus, negatively impact the production yield and quality. Some growers described that too much pollination and abundant fruit set will give result in extensive thinning work being required.[8] Too much thinning work can be very time consuming and expensive for growers. One of the growers, who perceives the pollination conditions on his farm as sufficient without renting bee hives, said: "If we get a lot of flowers and some really nice days during the bloom, and anything that can go well goes well, and trees set 100%, then we have a huge problem" (A1). Most of the growers do thinning work manually, and, in large-scale productions, they would need to hire extra labor to do additional thinning work. The same grower (A1) explained that high expenses in thinning work can potentially result in a problematic loss of income. He also raised the concern that too many apples on the trees as a result of abundant pollination would cause challenges for his support

8 The aim of thinning apple trees is to remove excess fruits in order to get fewer, bigger and better-quality apples.

system. In general, this grower explained that he normally gets higher yield than average production volumes in the district, and his support system may not be able to handle higher apple volume. He said: I must regulate tree growth in the fall to avoid too much thinning and to increase quality. That is the goal. Diameter is everything!" (A1).

Several growers agreed with this understanding to some extent, that abundance of honey bees possibly can lead to increased thinning work. On the other hand, several other growers perceived it as a risk worth taking to ensure good quality; they said thinning work is a basic task that would be done anyway. Growers explained that getting too many apples is a regular occurrence, and many factors affect the fruit set development besides pollinators: "Recent years, there has been a lot of thinning work. It is linked to the number of flowers you get, field management, and temperature during bloom," one grower said (A10). Another said: "There cannot be too much pollination. If many bee hives were placed out, it could only be positive. I would rather put in more thinning work and labor" (A11). A third grower agreed with this understanding and described too much pollination as a luxury problem (A6). If an abundance of honey bees contributes to improved pollination and fruit quality, there will be more high-quality fruit after thinning the trees: "If it is like I believe, there would be apples anyways, even with bad pollination, but of poor quality and then you need to remove them. So, it is better to have sufficient pollination and then remove excess fruits arbitrarily. It is time consuming and almost impossible to sort fruit if some of them are bad. It is better that all of them are good because of good pollination. Then you can remove 80% and have 20% remain that become big and nice" (A9). The one grower, one who for the last 10 years has placed an abundance of bee hives close to his fields, explained that he did not notice any increase in thinning that can relate directly to the use of more hives. He said that thinning apple trees is one of the most important quality measures (A6).

Benefits for Beekeepers in Doing Pollination Services

A Place to Station Apiaries and Build Strong Bee Colonies

The main goal of beekeepers interviewed for this study is to produce high honey yield; therefore, in early spring, their goal is to strengthen and build a strong colony of healthy bees. To achieve this goal, they aim to place hives in suitable places where bees can find nutritious and pollen-rich plants throughout the season. There was consensus among beekeepers that apple flowers provide limited pollen and nutrients for the bee colony, compared to other early blooming plants like Goat willow *Salix caprea* or Dandelion *Taraxacum officinale*, flowers which are just as important for honey production (B1). One beekeeper said: "For the sake of the beekeepers, we do not get much honey out of it [placing hives in apple fields], but it does offer a supply of natural pollen and some nectar in the early stage when bees are getting strong" (B3). Apple flowers in an orchard could serve as a significant food source for bees as they flower early with many flowers at a time. Some beekeepers described that whether or not it is important to place hives near apple orchards depends on what access the beekeeper has to locations that support a high honey yield later in the season. Those beekeepers who do not have access to rich and nutritious environments will have need for apple orchards to build up the colonies, and *vice versa*. One beekeeper explained: "The benefit is not very big, but it is OK. Others might benefit from it [having hives in orchards] more than us, for those who have worse forages. We have a good summer forage" (B2).

Most of the apple growers also shared this understanding and are aware of the limited pollen and nutrients from apple flowers. However, some growers perceived placing honey bees in an orchard as very favorable for the bee colony and that having bee hives in the orchard would be equally beneficial to the grower and the beekeeper.

According to the beekeepers, placing bee hives in apple orchards to build a strong colony is therefore only a partial reason for providing pollination services as a business. There are other incentives that motivate the beekeepers more. For example, many beekeepers need a geographical area to station their apiaries. One beekeeper explained that he needs areas to place his apiaries as he does not have a farm or enough other land of his own on which to place them (B1).

There are different practices by which beekeepers make deals to place their hives. Some of the beekeepers move their hives between bloomy fruit and berry cultures while others make deals with growers to keep them placed until the end of summer, while yet others have them placed close to apple farms throughout the year. Beekeepers who are dependent on finding a good early spot for their hives may choose to place their hives at the grower's apple areas. They often do not receive any payment from the growers. They see it as a mutual exchange. Many beekeepers often have multiple arrangements with various landowners. Some of the beekeepers in this study rent bee hives for tunnel productions. Most of them do a combination, both in terms of where they are placed and whether or not they receive payments for the bee hives. One beekeeper explained: "We mostly have fixed places and pay the landowner, either with half a kilogram of honey each year per hive or with money. They can choose if they want money or honey and most chose honey. Those who want hives at their place, they pay us" (B2).

Pollination Service Business Provides Additional Income

One of the major reasons beekeepers choose to rent out their hives is because it provides additional stable income alongside honey production. Especially in years when honey yield is lower, due to, for example, unpredictable weather events, honey bee health, or frequent bee swarms, beekeepers appreciate having an extra source of income. One of the beekeepers said: "The yields vary a lot from year to year. In this area the summer forage is not so good. The fall forage is much better. So, if the fall foraging goes wrong, then it makes a huge impact on the total yield, which is your income" (B2). Another grower expressed: "The benefit for me is the 600 NOK. I could just as well have had them standing in another place" (B3). All of the beekeepers describe a positive development in the beekeeping economy the last decade. The economy in honey production has improved significantly due to market demand and higher honey prices, and beekeepers perceive their operations as profitable today. Still, pollination services are a bonus for many of them. However, many of the beekeepers predict a slight change in honey prices since there has been a growth in the number of beekeepers and the market may become over stimulated. If honey prices fall, pollination services could be a good supplemental source of income.

Desire to Contribute to Agricultural Productions

All the beekeepers explained that their reason for becoming beekeepers was due to a fascination with bee biology, honey bees, and how they behave in nature. Many of the beekeepers expressed that they would like to contribute to the local agricultural production because they believe honey bees are very important for fruit production. Similar to many apple growers, beekeepers believe honey bee pollination is important in fruit production to achieve optimal apple yield, apple quality, proper fruit development, as well as extra security from cold weather during bloom.

Many of the apple growers pointed out that beekeepers understand the honey bee pollination processes and its benefits in fruit production very well. They added that many beekeepers know where hives should be placed on the farm and how bees fly. Most of the beekeepers agree with this understanding. One beekeeper said: "I believe we beekeepers consider honey bees as even more important in production than many fruit growers. (…) We observe the bees and see how they work and behave. And since I am both a beekeeper and cherry grower, I assume I am more aware of the benefit from honey bees than many others" (B4). Further, they said that honey bees work differently than wild bees in how they pollinate; honey bees pollinate the flowers systematically. There may not be enough wild pollinators to do a proper pollination job in terms of quality and yield effect, said some beekeepers, which makes honey bees very important to production. Honey bee pollination may be even more important as production in Midt-Telemark increases, emphasized the beekeepers.

Beekeepers also mentioned they appreciate the social aspect of beekeeping and renting out hives, and enjoy being in contact and communicating with growers in the district. One beekeeper, who manages hives with her father, said: "It is social and enjoyable traveling around to the growers. That is not something you should underestimate either. My dad, at least, really appreciates talking to people here and there" (B2).

Challenges in Today's Pollination Services Business

Several apple growers believe that the pollination services system, which connects apple growers and beekeepers, works fine in its current state. Some explained that they normally contact beekeepers if they want to rent hives and that not so much organization is needed. Several apple growers expressed an adequate availability of hives in the district. On the other side, most beekeepers revealed challenges in how pollination services are run today in Midt-Telemark.

Lack of Organization

This study revealed that there is a consensus among participants that the pollination services business is informal. Most of the beekeepers expressed a lack of organization and some challenges on the institutional level. How the pollination services business is organized today is regarded by most beekeepers as time consuming and inefficient. One of the reasons for this inefficiency is that multiple growers rent only a small number of hives each. Some beekeepers try to avoid orders that are too small and practice a minimum five hives policy. There are growers who rent as many as twenty-two hives, and this is easier to administrate. Small orders require a lot of time, for transport and maintenance. The beekeeper who runs the largest pollination service business in Midt-Telemark explained: "Since I have so many bees I do not have time to manage my bees *and* travel on pollination missions *and* at the same time do queen rearing. All of this happens at the same time. (…) And about the pollination part, you should deliver the bees at the right time, place them around in the orchards which takes time, so perhaps the farmer decides to spray with chemicals and then the bees must out" (B3). The same beekeeper said that apple growers often call before they have to spray apple fields, but when the beekeeper is managing approximately 100 hives distributed out in the district, it takes time to collect and find a new place for them. Moving hives too much may also disturb the bees. The current inefficient and time-consuming system is one of the reasons why he considers quitting his pollination services missions, which provide bee hives to about 10 apple growers. In order to continue his missions, the beekeeper explained that he is dependent on getting new arrangements with landowners so that hives can stay in the orchards more permanently.

Thus, pollination services – in terms of transporting and maintaining hives – requires a lot of work and takes time. Therefore, many beekeepers would like to get paid for the work they do. Some explained that setting a pollination fee can be challenging but they try to stick to NBA´s suggested prices to avoid any disagreements between beekeepers. It currently costs between 500 and 800 NOK per hive to rent in apple orchards in Midt-Telemark. Whether this is seen as a fair price varies among beekeepers. A few considered the pollination fee to be fair because of the high number of beekeepers available in Midt-Telemark, but most of them perceived the pollination fee to be low compared to the time involved in doing the job. Instead they proposed a price tag closer to 900-1200 NOK for each hive. One beekeeper said: "I would be interested in increasing pollination missions, but the price is a little low. (…) I would never keep bee hives just to rent, then the price would have to be better" (B2). Some also propose a minimum price at 2000 NOK when ordering under four hives. (Notice that when beekeepers were asked about suggestions for fairer prices they did not make any careful estimates. The answers were their immediate suggestions).

Many of the beekeepers explained that growers often agree with the current price, especially among those who rent bee hives today. Apple growers explained that they are willing to pay for bee hives and do not see bee hives as a large expense when compared with their overall costs. However, both beekeepers and apple growers noted that to what degree apple growers are willing to pay will depend on how they perceive the added benefit from pollination services. One beekeeper explained: "The recipient wants the bee hives, but they are not willing to pay for more. It is too big of an investment for some growers because they are uncertain about the effect on yield" (B5). Another beekeeper, the fulltime cherry grower who uses his bee hives in his own production, said: "A not so good thing is that many fruit growers look at pollination as an expense, and do not want to pay much for it. But they spray and fertilize even if it might not be necessary that year. This is not how it is regarding pollination. One year you might not need pollination because you got nice weather, and then it is perceived as a cost. (…) I notice, those growers who do the right things and put more money into the production get better results over time" (B3).

Another consideration is the possible competition between beekeepers for places to keep their apiaries, which makes it harder to demand payment for the pollination services.

Increased competition is due to the significantly increased number of beekeepers in Midt-Telemark. This situation affects the pollination service business in Midt-Telemark today. One beekeeper highlighted the importance of making good arrangements with landowners (B1). As explained above, he can place his hives close to fruit growers´ orchards as a mutual exchange, without receiving any pollination fee. One challenge he described is that, since bee hives should be separated and not too close together, finding an appropriate distribution of hives can be somewhat challenging. Several of the beekeepers agreed with this assessment and explained that they demand a pollination fee for hives placed out to tunnel growers (because there is higher bee loss) whereas hives may be placed in orchards at no cost to growers.

Some beekeepers also explained that they would rather pay with money than with honey, for economic reasons, but paying with honey is a traditional way. In many cases, the collaboration between beekeepers and apple growers is based on traditional arrangements. Some beekeepers explained that since the previous generation placed hives for free, it has been hard to change. This remains true even if awareness spreads among growers of the positive effects of added bee hives.

Today, several of the beekeepers explained that they use both written contracts and oral agreements, depending on the situation, when placing bee hives. Written contracts are, for the most part, only practiced when growers rent hives and pay for them. One beekeeper explained: “We send an invoice but have no written contract. This is a small place and we know each other. If I operated on a larger scale with strangers, I would use contracts” (B2). Many participants expressed a potential for improving the content of the contracts, to have more clear agreements and a mutual understanding on how to operate. For instance, contracts seldomly contain any agreements on practices on cutting of Dandelions or other flowers in bloom in the orchard, which can harm the bees. The most common elements found in a written contract are time and place, number of bee hives for delivery and pick-up, as well as agreements on spraying practices, including growers’ responsibility for following agrochemical restrictions. If not followed, the beekeepers can claim compensation for loss of bees. Still, a common practice among growers is to call beekeepers to inform that hives should be removed when growers plan to spray. One beekeeper then explained: “If I do not

have time to move the bee hives I tell the grower that if he promises to spray after 22:00 and before 04:00 in the morning, then I will take the risk and let the bee hives stay. And they remember the contract and its compensation part. But you cannot control what the neighbors are doing" (B3). Some beekeepers also expressed a desire for more multi-year contracts which are more convenient for both parties and provide more predictability.

Concerns About Growers´ Field Practices

Most beekeepers did not experience problems with excessive bee death when placing hives in apple orchards, despite the risks agricultural practices can potentially cause bee colonies. Several of the beekeepers described the growers as very professional, taking precautions to protect the bees. The beekeepers trust the growers, in terms of following spraying restrictions in blooming time and avoiding spraying when insect pollinators are out flying. Many of the participants believe attitudes have changed among growers since the last generation in how they understand the importance of protecting bees. One apple grower said: "I believe bees are important. I look for them and get happy when I see them in the field. I try to do what I can to not do any harm to them when it comes to spraying" (A9). Additionally, a lot has changed regarding restrictions on the use of and content of agrochemicals. Thus, some beekeepers are less worried and do not believe it is risky to place bee hives close to agricultural productions today.

However, some beekeepers raise concerns about the use of agrochemicals during bloom. The biggest concern are large-scale growers and what some expressed as "moon shine growers"[9] and to what extent they follow spraying restrictions. Another concern is growers´ neighbors (can be growers of other cultures e.g., grain). Their spraying of pesticides cannot be controlled. One of the beekeepers explained: "If you have a large production, you might not have time to spray all of it during the night, so they must do it during daytime as well, which is a bit concerning for the bees. It is a paradox that growers rent bees to pollinate and then perhaps the neighbor sprays and harms them. It is a tricky situation" (B3). One of the full time beekeepers in this study described his experience of losing bees after renting out hives to a

9 Meaning "måneskinnsbønder". Expression used by some participants about growers who have a full-time job in addition to being an apple grower.

fruit grower; he does not rent out hives anymore because of this: “The colony was reduced, and I did not get expected honey yield from fall forage. The grower did not adhere to the spraying restrictions and bees were rejected from the bee hive due to the foreign sulfurous odor. Sulfur itself is not harmful” (B5). The beekeeper further explained that the bee hives were placed in the orchard for the whole summer to have a permanent resting place. When he became aware of the problem, and saw fewer foraging bees, he stopped placing hives close to orchards (B5).

Most apple growers described chemical restrictions and rules as easy to follow, and only a few perceived the set restrictions as unclear and hard to interpret. Some growers also expressed their concern about honey bees and use of agrochemicals. One grower said: “It is scary that you can kill the bees. Accidents can happen. If you have bee hives in the orchard and spray, then some bees die; that is not an easy thing for growers either. (…) I question whether the restrictions are sufficient, and if it is enough to only spray at night. Will the bees die anyway? This is difficult to figure out” (A9).

Another issue pointed out by most of the beekeepers are growers´ practices of cutting grass and flowers between rows in orchards during bloom; this can kill the bees. In the blooming season additional flowers, such as Dandelions, are to be found in the orchards which can serve as important forage for the pollinators. Many apple growers try to be careful and are aware of the problem cutting grass can cause but like to keep their orchards tidy. Some growers express that they are unsure about what is the best practice to keep bees safe. One beekeeper said: “Most growers do not cut grass during the daytime, but you have some exceptions. And you do not need many of those before it goes wrong” (B4). Another beekeeper explained: “There are no official rules for it [cutting flowers between rows] and I do not think the growers are very aware of this problem. But beekeepers have maybe not been good at informing them about this either. (…) Goat Willow and the Dandelion are important too. We need the total package” (B4). Some beekeepers explained that they try to encourage growers to leave the early flowering plants or avoid cutting during the day. However, some growers pointed out possible challenges with leaving flowers between apple rows. “What is challenging is that bees also forage on Dandelions. They prefer yellow flowers more than apple flowers, and they bloom at the same time. What you can do is to cut the

grass before bloom. But you need to be careful and do it in the evening, at night or early in the morning. It is important to be careful about this" (A9). One beekeeper explained that bees can be found on dandelions at one time of the day, and on apple flowers, for instance, later in the day, depending on the temperature and the development that day. Most of the beekeepers, as well as some growers, expressed that practical information and knowledge about this topic is limited and requires more attention. Another beekeeper pointed out: "We must cooperate on this, it is about living organisms" (B2).

Areas for Improvement and Suggested Actions

Most participants see potential for developing the pollination services business in the district. According to participants, there is a small but increasing demand for renting pollination services today, especially among young, new producers. All the beekeepers expressed a desire to continue with honey production on a large-scale, and several said they are willing to do more pollination service missions and are interested in offering bee hives to apple growers. However, results from this study showed that the current organization is not optimal for beekeepers and that there is a great potential for improvement in the pollination services business in Midt-Telemark. All participants suggested actions for improvement with the goal to improve organization and collaboration as well as increase attention and knowledge of the role of pollination in fruit production.

Increase Attention, Information and Knowledge on Insect Pollination in Fruit Production

Even though most participants described a slight increase in attention directed towards insect pollination in fruit production in Midt-Telemark today, participants agreed that this topic should be given even more recognition within the apple and beekeeping community, including the local NLR and NBA.

All apple growers expressed a wish to acquire more knowledge about insect pollination in apple production. Most participants also requested more documentation and evidence by which honey bees can affect yield and quality in various conditions for apple production. They

believe more research and documentation will be an important step towards encouraging growers' willingness to pay for these services thus increasing the pollination services business. One beekeeper pointed out: "I would like more information. That will also bring more attention to the bees. They are extremely important. Many want more knowledge, and many also says that the hinderance in increasing the pollination services is lack of knowledge" (B5). An apple grower said: "I believe that if we get more documentation on the effect than we have today, whether honey bees affect the yield, then there will be a bigger opportunity to offer pollination services" (A5). Many apple growers, as well as beekeepers, want more agreement and clear information on what practices to implement during bloom season, especially regarding the cutting of grass and flowers, e.g., dandelions. They would also like to increase attention on the importance of following spraying restrictions. Some participants suggested creating a set of standard practices to follow that can help the grower doing the right practices in ensuring the safety of the honey bees placed in the orchard and follow beekeepers' requirements.

Until now, most information on pollination and recommendations to apple growers for using honey bee hives have been provided by NLR, but to a limited extent. Participants believe NLR will play a crucial role in providing information about insect pollination in apple production within the apple farming community. Advisors from NLR and their agricultural support are valued and trusted by the apple growers, both by the new and well-established. Many participants pointed out that NLR and the NBA, should reach out to young and newly established apple growers in the district to encourage establishing honey bee hives as a commonplace practice just as fertilization, spraying, irrigation and thinning are today. Some participants believe that these younger growers are more likely than older, more established growers, to adopt to new ideas and practices. Some growers also emphasized the importance of keeping new information for growers practical and concise, with a "if you do this, then you get this"- perspective.

Some apple growers also pointed out that certain information and knowledge should be updated from NLR and NBA. As mentioned above, most of the apple growers were uncertain about how many bee hives that are recommended to be used in the field, depending on size. One beekeeper explained that NBA have provided information about how many hives to use,

but this information needs more attention and an update. However, some beekeepers also pointed out that how many hives to use will depend on location and the production, and for those who want to rent hives they should start with a few and test to see the effect. If growers do not see any significant effect, they can try with more bee hives.

Participants suggested more information on insect pollination in fruit production through the following arenas and platforms:
Fruit producer meetings: Seasonal meetings facilitated by fruit growers in the farming community should include information about pollination services. Some participants suggested beekeepers to attend and inform growers about their services. Some growers explained that meeting the beekeepers providing pollination services and being able to ask questions and knowing who to contact, would make it easier to make an order later on.
Arrangements: Professionals speaking about pollination in fruit production. This has been tried once in Midt-Telemark earlier but with less success. Therefore, some participants suggest making a bigger engagement in advance to ensure attendance of the farming community.
Information letters: Either through email or in journals issued by NBA, NLR or other professional agricultural sources.
Create a common information platform: Create a platform or forum, or even a Facebook group, to share relevant information about the honey bee pollination services business.

Many apple growers suggested that beekeepers should be more visible in the farming community and market themselves. Several apple growers believe increased marketing on offering of pollination services is important for increasing awareness and is key to action.

Increase Collaboration Between Actors to Improve Organization

Many participants suggested strengthening the collaboration between apple growers and the local Beekeeping Association. Both communities are described by many of the participants as large and active with many engaged members. Several of the participants proposed creating an organization on pollination services, facilitated by NLR and NBA. This could be a pathway for communication and an opportunity to create a learning platform, where beekeepers and

apple growers can get advice and share knowledge and information about bee hive availability, contact information, prices, common bee hive stations or general experiences, ensuring everyone in the community have access to the same information. Some beekeepers proposed that this group emphasis should be on pollination services, in a more professional manner.

Another suggestion is implementing common honey bee hive stations for pollination services, called “grendepollinering”. The concept of “grendepollinering” involves that beekeepers place apiaries in a specific chosen area close to surrounding apple orchards, and apple growers involved share the expenses. Participants explained this collaborative solution as more effective because it enables beekeepers to save time and resources and, as a result, possibly have the ability to serve more producers. Participants also explained that “grendepollinering” can be a way to have some bee hives placed more permanently during the spring.

Some participants suggested that the NBA and the apple community could work together to improve pollination service contracts between growers and beekeepers so that they contain more specific requirements and guidelines, benefiting the beekeeper and the apple grower. These contracts may require beekeepers to deliver strong and healthy bee colonies for the apple growers. Especially if “grendepollinering” is to be implemented. Offering strong bee colonies are highlighted among both beekeepers and apple growers as an important factor when renting bee hives. One beekeeper said: “The strongest and greatest bee hives are placed out for pollination. In respect for those who rent. We trust them and are not afraid of our strongest hives” (B2).

4. Discussion

Apple Growers' Perceptions on the Need for Managed Honey Bees Hives

The results showing that growers who use honey bee hives in their apple orchards experienced increased yield and quality are in line with previous studies (Geslin et al., 2017; Samnegård et al., 2019; Stern et al., 2001; Åström et al., 2014). Increasing the density of honey bees in orchards can help provide sufficient pollination, increase the amount of cross-pollination, and result in greater fruit set and yield (M. P. D. Garratt et al., 2014; Stern et al., 2001; Åström et al., 2014). Well-pollinated apple flowers can also improve fruit quality, both in terms of seed and fruit development as well as the fruit's storage capabilities (Geslin et al., 2017; Norwegian Beekeeping Association, 2013; Samnegård et al., 2019). Honey bees were perceived by several growers as a necessary input to achieve their yield goals in terms of apple size, quality and stability.

All growers agree with current understanding which indicates that honey bee pollination is important for fruit yield and quality (J. B. Free, 1993). However, not all growers feel a need to rent bee hives; some feel there is already an abundance of honey bees and sufficient pollination. The reason there are different perspectives on the need for honey bee hives to supplement native and local pollinators may be that farmers are in different locations and landscape and weather conditions may differ from one place to another; this may affect pollinator visitation in orchards. Specific pollination requirement depends on the growers' location and environment as well as crop variety (Allan, Kesvan, Kleinschmidt, & Anning, 1993; Norwegian Beekeeping Association, 2013). With respect to this, an interesting finding from my study shows that one of the growers, who is known for being a skilled farmer, following recommendations from the extension services, and who is known for doing the "right practices", does not see the need for renting honey bee hives, even if this is suggested. This indicates that some growers may already be located in favorable conditions with sufficient coverage of pollinators.

Some growers observe bumble bees in their orchards during bloom and perceive good overall numbers of honey bee pollinators at their location; this is why some do not see a need to rent

honey bee hives. This understanding is supported by literature which shows that wild bee species can contribute to effective crop pollination, if they are numerous and healthy and have favorable surrounding habitats (Delaplane et al., 2000; Fløystad, 2018). Having a diversity of pollinators, which can include supplemental support from honey bees, contributes to effective pollination (Brittain et al., 2013). However, several growers did not see a sufficient contribution from wild pollinators, and not all participants perceived wild pollinators to be enough to ensure sufficient pollination in their orchards. This can be linked to the global decline in pollinators, also seen in Norway (Henriksen & Hilmo, 2020; Potts, Biesmeijer, et al., 2010). At the same time, previous studies done in Norway show that apple orchards have had significantly more visitation from honey bees than wild pollinators (Åström et al., 2014). This underscores why participants value managed honey bees to support pollination services and secure stable pollination.

Additionally, several participants pointed out that renting managed honey bees will be more important in the future as apple production areas grow in Midt-Telemark. This same perspective is also presented in previous literature explaining that population of wild pollinators are often too small to support commercial pollinator needs and honey bees may be more important the bigger the production is (Isaacs & Kirk, 2010; Levin & Waller, 1989; Norwegian Beekeeping Association, 2013). On the other hand, since some growers described an increase in yield in previous years even without additional honey bees, despite a possible decline in pollinators, as well as increase in production areas, this theory may not be applicable to all areas in Midt-Telemark. With that being said, Norwegian fruit production areas are still relatively small compared to international large-scale productions, which may also indicate that managed honey bees to support pollination services may not be necessary for all growers. However, this will depend on the future development of wild pollinator numbers and diversity.

Findings from my study showed that some apple growers are concerned that more abundance and visitation from honey bees will require an increase in thinning work. This correlates with previous research which says that pollination density can result in larger quantities of apples but smaller size, and that thinning work will be important to regulate fruit set (M. P. D. Garratt et al., 2014; A. M. Klein et al., 2015). Thus, these growers do not perceive

a need to rent honey bee hives in their production as it may result in higher production costs, and apple growers may have to deliver more apples to be able to compensate for the added thinning costs (M. P. Garratt et al., 2014). Growers who perceive the abundance of honey bees as an unwanted cost, in terms of more thinning work, contradict recent studies done in western Norway, which suggest that increasing honey bee density can improve yield and income (Grofondet, 2019; Norwegian Beekeeping Association, 2020). However, as most of the growers in this study emphasized, excessive apple fruit that is well pollinated can also be a way to assure better quality apples after thinning (Åström et al., 2014). The disagreement among apple growers indicates that they may have implemented different practices as there are many different thinning methods and factors (such as time of thinning) that influence on apple yield and quality (NLR, 2017). Another reason for the difference in perspectives could be that there is a general lack of research on how to regulate apple trees when using more honey bee hives and how the two factors are linked, and hence a lack of this knowledge in the farming community, including within NLR.

All growers expressed an understanding of how inputs and practices, such as water availability, soil nutrients and accurate use of fertilizer, pest control and thinning practices, in combination with pollination services, are important for fruit yield and quality in crop production (M. P. Garratt et al., 2014; A. M. Klein et al., 2015; NLR, 2017 ; Ola Lundin, Smith, Rundlöf, & Bommarco, 2013; Åström et al., 2014). Conversely, positive pollination effects on crop yield can be reduced if these other factors are not optimal (Bommarco et al., 2013; A.-M. Klein et al., 2007). How all factors interlink and are interdependent indicates that the positive effects several growers perceived on apple yield and quality from using honey bees could be related to changes in other factors which align with the same year when they started to use more honey bees. For instance, favorable weather (higher temperatures and less precipitation and wind) will increase the activity of pollinators (Vicens & Bosch, 2000). Several growers also expressed a development and change in farming practices previous years, due to the new advisor in NLR and his influence on apple production. Thus, new and better methods, for example, more use of fertilizers, combined with favorable weather, could have impacted the results in terms of yields that the participants experienced the year they started with bees.

Results showed that many participants are uncertain about the effect honey bee pollination has in different farming conditions, including how effective bees are in spring when weather can be cold or rainy and there can be frost. A few growers believe honey bees would not help in cold weather, which is in line with previous literature above. However, results also showed that most farmers appreciated the contribution from honey bees when there were cold or unstable weather conditions during bloom. Even tough honey bees are more active when temperature reach 9-10 degrees Celsius, if bee hive management from beekeepers has been successful and hives are strong, honey bees will be ready to pollinate as soon as weather changes (Geslin et al., 2017; Norwegian Beekeeping Association, 2013). That growers who rent hives today as a security measure in case of poor weather conditions may indicate that they have experienced and observed this effect and choose to continue renting bee hives. Since growers wish they knew more about the effects of honey bees, including how honey bees behave and act in different weather conditions, there should be done more research on this topic.

Many apple growers in this study seem to lack knowledge about how sufficient pollination can affect the nutritional composition of the fruits, something they mostly linked to fertilization practices and water availability. Ensuring sufficient pollination may positively affect calcium (Ca) concentration in some apple varieties, which is an important nutrient in apples to keep adequate quality under long-term storage (NIBIO, 2017; Samnegård et al., 2019). Growers have been encouraged to establish varieties suitable for long-term storage, such as Rubinstep, in order to be able to sell apples later in the season. However, the lack of knowledge among growers indicates that there may have been less attention on pollination services as a part of the strategy to produce apples for long-term storage. This may influence growers´ perception of the need for procuring honey bee hives for their production. At the same time, it shows that using pollination services to a greater extent than today may be important in future apple production in Midt-Telemark since long-term storage is one of the main goals for Telefrukt.

One other important trend within my research is that multiple growers reflect on the reasons for why they achieved positive yield results in certain years and not others. They reflected on what could have been impacting production and whether good results were connected to

honey bee colonies close by or simply a coincidence. This may indicate that growers try to understand how varying factors and mechanisms interact in apple production. Such reflection on experiences and observations are important, since it is a part of the development of farmers´ intuition, and again this intuition is an important contributor to successful decision making and farm management (Nuthall & Old, 2018). Thus, growers who observe more in the field and reflect on how ecological functions are connected, such as honey bee pollination in apple production, are more likely to choose inputs that are best for their production.

There are different perspectives on the need for honey bees: while some growers express a lack of documentation on the effects of honey bees on apple production, others perceive a strong need for additional bee hives close to orchards. This indicates that growers might base their decisions and perceptions on their own experiences, as well as traditional views. This is in line with the literature which explains that many growers may follow traditional practices passed down from earlier generations (Feola, Lerner, Jain, Montefrio, & Nicholas, 2015).

Beekeepers´ Interest in Offering Honey Bee Hives

Interviews with beekeepers revealed that pollination services offered to apple growers make up only a small part for the beekeepers´ income, whereas the majority comes from honey production. At the same time, most beekeepers explained that one of the reasons they want to offer pollination services to apple farmers is because it could provide an additional stable source of income alongside honey sales. However, as the honey prices have increased and the beekeeping economy has improved (Haug, 2018), most beekeepers in the study believe the money they earn from pollination services are too low given the work involved and time spent in the logistics of managing honey bee hives. Therefore, changes in the organizational structure and/or the pollination service fee seem to be crucial to increasing the extent of pollination services in the future. If beekeepers are not able to charge enough for pollination services, it may not be prioritized by the most active beekeepers as a business, since honey production is their main goal.

In contrast, pollination services for agricultural crops are a big business and the main part of the commercial beekeepers´ income in other countries, including the United States (Bond, Plattner, & Hunt, 2014; Burgett et al., 2010), but research show that the pollination fee can depend on that year's honey prices, as well as how much honey bee foraging activity from the orchard will contribute to honey yield (Rucker, Thurman, & Burgett, 2012). My findings show that beekeepers may offer pollination services in order to find a location to place their hives and build up honey bee colonies from apple flower foraging, and this may therefore impact and reduce the pollination fee (ibid.)

With respect to apple flowers and honey flow, literature that clearly analyzes nectar and pollen contribution from apple flowers is sparse. Regardless, beekeepers´ impression that apple flowers contribute to limited nectar and pollen is in line with recent studies (Breeze et al 2018) explaining the similar perception among other European beekeepers. Previous literature shows that availability of other favorable plants, including Dandelion, can also be a nutritious forage for honey bees (J. Free, 1968; Kirkevold & Gjessing, 2003, p. 125). This implies that beekeepers have been accurate in their perceptions of apple nutrition. It also indicates that their perception on the benefit from apple flowers are based on their own experiences. It further indicates that for some beekeepers, who can access other suitable forage locations, the potential earnings from pollination services will be crucial in determining whether they choose to provide these services.

Studies also show that honey bees may in fact prefer apple flowers, as their foraging behavior involves “flower constancy”, meaning they will concentrate on specific abundant species, such as apple flowers in orchards, even though competing flowers are available (Allan et al., 1993; J. Free, 1963; Waser & Ollerton, 2006). Correct pollination management, meaning introducing bee hives at the correct time, right when apple flowers are in bloom, can have a big impact on such forage behavior (Delaplane et al., 2000). This supports the beekeepers´ assertion that apple flowers can be important for those with limited access to apiary locations and good forages later in season.

Another reason for differing perceptions among beekeepers, and why some perceive a need for early forages in apple orchard, may be due to a difference in bee hive management

practices. This could be why some believe access to early forages in apple orchards is important while others do not. Bee hive management can determine whether the bee colony is prepared for the forage season; this is achieved through the right management practices. Having a strong bee hive ready in the spring can potentially allow those bees to reap the reward of early forages (Doeke, Frazier, & Grozinger, 2015; Mattila & Otis, 2006). For the beekeepers who do not have a strong colony already in the spring, placing hives in an orchard with an abundance of flowers will be favorable and important. Some of these beekeepers would not receive pollination revenue but would rather offer bee hives for free as a sort of mutual exchange. Thus, beekeepers who seems to largely depend on the overall access to good forage places, do not have the same opportunity to rent out their hives and offer pollination services for a cost.

Results show that the viability of the pollination services market will largely depend on growers' demand for bee hives as well as their willingness to pay. The demand depends on whether they perceive they have a need for additional pollinators in their orchards to achieve their production goals. However, in my study, where participants explain that the current pollination fee is seen as a small expense among most growers, as compared to overall production expenses, and most of them express a willingness to pay for bee hives, indicates that most growers in this study think there are advantages to having honey bee hives close to their orchards. It may also indicate, that there is a balance between beekeepers' willingness to offer pollination services and apple growers' interest in renting. This can lead to further opportunities and potential to further study, expand, and improve the pollination service business in Midt-Telemark today.

Several of the beekeepers in this study expressed concern about the use of agrochemicals, especially application of Sulfur and how it may harm bee colonies when they are rented out to apple farms. Previous research shows mixed results on how pesticides impact honey bees, but there is legitimate concern about possible negative effects (Pettis, Johnson, & Dively, 2012; Potts, Imperatriz-Fonseca, et al., 2016; Vidau et al., 2011). Luckily, the use and approval of pesticides has become more strict, due to the European Union (EU)´s recent restrictions (European Commission, 2018). To protect insects, growers also need to follow restrictions for

time of application of pesticides (Syngenta, 2019). Most of the beekeepers did not experience any negative effects on their bees from renting out hives; they perceive current spraying restrictions as sufficient to keep bees safe. One beekeeper did have negative experiences placing bee hives in apple orchards, when he did not move hives after bloom. A reason for this difference in perceptions may be that only a few beekeepers have rented out multiple bee hives over the course of several years, whereas others only rented out hives for the short term. This may affect overall perception and experience of pesticide risk. Another reason may be that the bee losses were not necessarily caused by practices in apple orchards but may have been a result of practices of neighboring farmers which will be difficult to control and study.

Findings from my study, showing that one of the largest apple growers who wanted to rent bee hives but had difficulty in procuring them, and was the only one to experience this problem, may indicate that whether beekeepers are interested in renting out hives in certain apple orchards may also depend on the farmers' practices. If beekeepers find that spraying restrictions and timing are not being respected, which could be more likely in large productions, they may decide not to rent their hives to large producers. In this way, beekeepers seem to evaluate whether orchards are safe for their bees to be placed. A similar study done in other European countries shows that beekeepers were ambivalent in offering their hives to large productions. On the one hand it contributed to higher honey yield and bee colony growth, but, on the other hand, some beekeepers saw it as a risk of exposure to pesticides (Breeze et al., 2019). As mentioned earlier, Norwegian farms are often smaller than international farms, which could explain why most beekeepers feel it is safe to rent out their hives to most apple growers in Midt-Telemark.

The limited research which currently exists on how pesticides impact honey bees indicates that many growers evaluate the risk of pesticides from their own experiences or other information sources, such as non-academic the media. There is a demand for more research on pesticide use and its risks because of the clear uncertainties which currently exist on this topic.

Suggested Actions and Future Research

Increasing collaboration to improve the current pollination service business is perceived by participants to be an important way and opportunity to increase knowledge, share experiences, and learn from each other. These perceptions are supported by existing literature describing that collaborative learning, where you learn from each other's experiences, can lead to new solutions, knowledge and skills, and even strengthen relationships between stakeholders within the farming community (Gray, 1989; Källström & Ljung, 2005; Restrepo, Lelea, Christinck, Hülsebusch, & Kaufmann, 2014). Results from the study show that apple growers think beekeepers have valuable knowledge about honey bee behavior, and more collaboration on apple pollination may benefit both stakeholder groups, both in terms of finding solutions for how to better organize the system of pollination services, and the exchange of knowledge.

It is important to point out that there is a long tradition of collaboration between farmers within a farming community. Results from my study show that there are active and engaged members both in the apple grower community and the local beekeeping community. This is a great potential for implementing new measures and a stronger collaboration between the two stakeholder groups. For instance, they can agree upon and make field-practices clearer for growers, as it is clear that most growers want to do the right thing.

The apple growers expressed uncertainties about the importance of insect pollination in fruit production, is because there are many factors which influence growth. It is therefore difficult to quantify the effect of honey bees. In this way, apple productions can be described as a complex social-ecological system (Restrepo et al., 2014). Such complex farming systems, where human, technical, and natural components are involved and interrelate, may lead to uncertainties and unpredictable outcomes (ibid). When growers experience uncertainty due to the complexity of the farming system it may affect their decision-making. This indicates that uncertainties expressed by participants on the impact of honey bee pollination may be a reason for why some growers do not presently rent pollination services in Midt-Telemark. Thus, it is important that farmers believe they have sufficient and correct knowledge about the complex farming system in order to make the right decisions for their production. Further

research is needed on insect pollination in apple production for growers to make informed decisions as to whether they should invest in pollination services. They need to be certain that honey bees add value.

A collaboration between NBA and NLR to initiate a pollination services organization could result in more research on the complexities of honey bee pollination on apple farms. The majority of participants expressed a desire to learn more. However, Suryanarayanan et al. (2018) describe that in collaborative research between scientists and non-scientists, e.g., farmers, the farmers can contribute important expertise, insight, and experiences which helps with understanding of complex real-world phenomena. Results from my study show that participants have important and valuable experiences and perceptions to share with colleagues within the farming community and could deliver important expertise and contributions to research alongside scientists and experts from NLR.

In addition, growers´ educational background in various professions and their previous engagement in learning apple production indicate that they may be willing to, and have interest in, adapting to new knowledge.

That most of the apple growers who do not rent bee hives seem to highly appreciate the contribution from surrounding honey bees in their apple production indicates an incentive to look at new solutions for collaboration and better ways to organize the current system of pollination services. It is evident that the current organization makes it difficult to do beekeeping on a large scale and at the same time offer pollination services. To improve the current ineffective and unorganized pollination services system, some beekeepers suggested looking at the same strategy used in the western part of Norway. The report from The Norwegian Beekeeping Association (2020) summarized the PolliVest-project and presented successful collaboration between beekeepers and growers, which improved yield results with implementation of “grendepollinering”. Results from my study indicate that implementing a similar strategy may be a way to get more apple growers who have apple orchards located in the same area to test the effect of honey bee hives in production. This could reduce the occurrence of “freeloading” and instead encourage farmers to share expenses. A system which normalizes paying for pollination services moves away from traditional organization

and attitudes. Therefore, a future project could be to start “PolliØst” in Midt-Telemark, as a research project, to improve the current pollination services organization and simultaneously study the effect of honey bee abundance in apple orchards. Honey bee pollination is a specific profession in which there is big potential to increase knowledge among Norwegian beekeepers who rent their hives for crop pollination (Norwegian Beekeeping Association, 2020). Thus, further work should also bring attention to how to implement more pollination management within apple production. This might include studying the importance of strong honey bee colonies, correct placement of hives, and timing of honey bee introduction in orchards which are not practiced in Midt-Telemark today, but recommended by several researchers to be important in order to ensure effective crop pollination (Allan et al., 1993; Delaplane, Thomas, & McLaurin, 2010; Doeke et al., 2015; Isaacs et al., 2017; Stern et al., 2001).

One limitation of this research is it is difficult to know whether growers answered correctly and honestly questions asked in the interviews, especially concerning their perception and evaluation of the importance of honey bees and practices done to protect them. With respect to the complexity of the topic, referred to in this discussion, certain perspectives and experiences may have been difficult to either recall or explain by the participants. Also, in attempting to contextualize their statements and descriptions, misunderstandings may have been introduced. It is uncertain whether, as a researcher, I have interpreted their descriptions and perspectives within the specific context of an issue correctly. My research has also been derived from a relatively small group of representatives, in the district, which may have excluded some perspectives on the study topic.

5. Conclusion

In this thesis, I have argued that apple growers in Midt-Telemark, Norway, have different experiences and perceptions regarding the need to rent managed honey bee hives as supplements to existing pollinator populations in apple production. It is a question of the best way to assure sufficient pollination and achieve desired productivity. According to all participants, honey bees play an important and valuable role in apple production.

Several apple growers believe there is a need for managed honey bees to support pollination services in their apple orchards. These growers see additional honey bees as necessary to improve and secure desired yields and quality, especially when weather conditions are cold and unstable and wild pollinators may not be sufficient. Some growers have indeed experienced more stable yields when employing honey bee hives.

However, the growth in the number of beekeepers and apiaries in the district supplies many growers with sufficient pollination; hence, many growers do not see a need to rent additional honey bee hives. It is evident that whether growers will need to rent honey bees depends on the overall abundance of pollinators in their area. A few growers believe an abundance of honey bees, due to additional bee hives in the orchard, can potentially result in extensive thinning work and higher costs, both of which are perceived by growers as deterrents.

Most beekeepers in this study expressed an interest in offering honey bee hives for apple pollination, mainly because it can contribute additional and stable income, which can be especially beneficial in the instance that honey yield fails. However, traditional ways of offering hives for orchards as well as several beekeepers' dependence on early forage (which supports growth of bee colonies) hinders the pollination services market potential. The current system of pollination services is perceived as time consuming and ineffective. Fixing this is essential to supplying more pollination services in the future.

In conclusion, here are some suggested actions for improvement, as derived from participant interviews. Suggestions include: increasing attention, information and knowledge on insect pollination in apple production; initiating more collaboration between stakeholder groups and

relevant actors; better organizing pollination services; agreeing upon practices to minimize potential honey bee harm; and, finally, freely exchanging knowledge within the community. The results identified a need for more knowledge on the effect of honey bee pollination in apple production and future studies are needed on this topic.

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Appendices

A: Interview guide. Apple growers

1. Om driften

a. Lokasjon
b. Alder
c. Type produksjon (eplesort, andre kulturer?)
d. Størrelse (dekar/trær, antall ansatte)
e. Foredling (pakkeri, presseri), salgskanaler, samarbeidsledd
f. Når startet du produksjon?

2. Motivasjon

a. Hvorfor startet du med epledyrking?
b. Vil du vurdere din drift som en drift med god fortjeneste?
c. Mål/ambisjoner for driften?
d. Tidsperspektiv på hvor lenge du kommer til å gjøre det?

3. Hvilke temaer dukker opp hos deg når vi snakker om pollinering og pollineringstjenester? (åpent spørsmål for å få frem umiddelbare tematikker)

4. Pollineringstjeneste

a. Opplever du det er tilstrekkelig tilgjengelighet på bikuber om du ønsker å benytte det?
b. Oppnår du ønsket avling og kvalitet på høstingen din?
c. Benytter du honningbier (PT) i din produksjon? Utdyp gjerne
    - Hvem du leier av, antall kuber, tidsperiode
    - *om NEI: Hvorfor ikke? Hvilke forutsetninger mener du må være tilstede for at du skulle begynt med det?*

a. Hvordan vektlegger du effekten av honningbier i feltet? I forhold til andre innsatsfaktorer?

d. Hvor mange kuber mener du epleprodusent bør ha for "optimal" fruktsetting / avlings-effekt?
e. Er det aktuelt for deg å benytte pollineringstjeneste i større grad enn før?
f. Hvordan er organiseringen rundt utleien? (Fungerer det bra, eller bør noe forbedres?
    - *Hva synes du fungerer bra?*
    - *Hva fungerer ikke så bra?*

g. Mener du det generelt finnes et potensial for å drive med utleie av kuber til pollinering?
h. Hvor ligger begrensningene i å leie kuber i større grad?
i. Hva skal i så fall til for å se en økning, mener du?
j. Hvorfor er det ikke flere birøktere som tilbyr pollineringstjenester i dag, tror du?

5. Verdisetting

a. Hvor mye betaler du for pollineringstjeneste i året? (pr kube, totalt)

b. Verdivurdering av pollineringstjeneste: Hva er rettferdig verdisetting av denne tjenesten?
c. Anser du verdisettingen i dag som fornuftig?
d. Hvordan vil du forklare forholdene rundt prissetting/ betalingsvillighet blant epledyrkerne?
e. Er det enighet om pris mellom birøkter og epleprodusent?
f. Hvordan tror du en kan komme frem til en rettferdig betalingsordning?

6. Kunnskap, informasjon, samarbeid

a. Hvordan er birøktermiljøet i dette området? Er du engasjert i noe?
b. Hvordan er fokuset på pollineringstjenester i området?
c. Mener du det er tilstrekkelig informasjon/rådgivning om pollinering og effekten av det?
d. Kunne du ønsket mer fokus/ informasjon/organisering om pollinering og effekten av det?
e. Tror du synspunkt/ informasjon er forskjellig fra dere og birøktere som leier ut kubene sine?

7. Praksiser i felt

a. Åpent spørsmål om erfaring og praksiser rundt pollinering i blomstringstiden.
b. Er det noen spesifikke tiltak / hensyn som blir tatt i blomstring for pollinatorer?
c. Opplever du at reglementet/ IPV er utfordrende å følge?
    - Kan du forklare retningslinjer/regler en må forholde seg til?
d. Merker du noe til klimaendringer i drifta? Hvordan spiller klimatiske forhold inn?
e. Utfordringer i driften generelt, og med tanke på økonomi og avling?

8. Prioriteringer og vurderinger (økonomi, tid, ressurser, risiko)

a. Åpent spørsmål om hvordan vurderinger tas, mtp ressurs og innsatsfaktor valg/ prioriteringer?
b. Vurdering av viktighet? Hva er viktigst å prioritere som innsatsfaktorer?

B: Interview guide. Beekeepers

1. Om driften:

a. Ditt bosted? og sted for bigårder?
b. Hvordan anser du din birøkt? skala: hobby/yrkesrettet
c. Bieart?
d. Størrelse: antall (produksjons)kuber, antall birøktere, hvor mange leier kuber?
e. Når startet du med birøkt?
f. Medlem av NB/HC (ja/nei)
g. Leverer du honning til Honningcentralen? Andre salgskanaler?
h. Alder

2. Motivasjon

a. Hvorfor startet du med birøkt, og hva er din motivasjon i driften?
b. Har noe forandret seg fra da du begynte? (drift, økonomi, fokus, info, organisering)
c. Vil du vurdere din drift som en drift med god fortjeneste?
d. Har du noen mål/ambisjoner for driften din fremover?
e. Tidsperspektiv på hvor lenge du kommer til å holde på?

3. Hvilke temaer dukker opp hos deg når vi snakker om pollinering og pollineringstjenester? (åpent spørsmål for å få frem umiddelbare tematikker)

4. Pollineringstjeneste

a. Hva mener du skiller yrkesrettet og hobby- basert birøkt? Definisjon
b. Hvor viktig er honningbie-pollineringen, i fht andre innsatsfaktorer, i produksjon, tror du?
c. Hvordan tror du epleprodusenter vektlegger effekten av honningbier i feltet?
d. Hvor mange kuber trengs for "optimal" avlings-effekt?
e. Hvordan er organiseringen rundt utleien?
    - *Hva synes du fungerer bra?*
    - *Hva fungerer ikke så bra?*
f. Hva inneholder en typisk kontrakt mellom birøkter og dyrker?
g. Mener du det finnes et potensial for å drive mer med utleie av bikuber til pollinering?
h. Kunne du tenke deg å starte med utleie av bikuber (evt. i større skala?)
    - *Om nei: Hvorfor ikke?*
    - *Hvilke forutsetninger mener du må være tilstede for at du skulle begynt med det, eller økt nåværende skala?*
i. Hva skal til for å se en generell økning, mener du?
j. Støtteordninger blant mer pollinatorinnsats. Hva tror du om det?

5. *De som drifter og leier ut pollineringstjenester:*

a. *Hva synes du fungerer bra?*
b. *Hva fungerer ikke så bra?*
c. *Hva mener du kan gjøres for forbedring?*

6. Verdisetting

a. Hva er prisen på utleie av kuber til pollinering, til epleproduksjon, i dag?
b. Hvilken nytte får *du* ved å ha kubene dine i eplefeltet?
c. Prissetting av pollineringstjeneste: forklare rundt dette.
d. Hvordan oppfatter du betalingsvillighet for bikuber blant epleprodusenter? Forklar.
e. Er det enighet om pris mellom birøkter og epleprodusent?
f. Anser du verdisettingen i dag som fornuftig?
g. Hva er rettferdig verdisetting av denne tjenesten, mener du?
h. Hvordan tror du en kan komme frem til en rettferdig betalingsordning?

7. Kunnskap/informasjon og samarbeid

a. Hvordan er birøktermiljøet i dette området? Er du engasjert i noe?
b. Hvordan er fokuset på pollineringstjenester i området?
c. Hvordan oppfatter du epleprodusentenes kunnskap og holdninger om pollinering?
d. Mener du det er tilstrekkelig informasjon / rådgivning om pollinering og nytten og effekten? for fruktdyrkere og birøktere?
e. Ønsker du mer fokus på dette? Hvordan?
f. Er det sammenfatning mellom birøktere og fruktdyrkere om pollineringssituasjonen?

8. Miljøvern og dyrehelse:

a. Kan du fortelle litt rundt utleie-praksisene gjennom en sesong?
b. Hvordan opplever du epleprodusentenes hensyn til bifolket i felt?
c. Noen tiltak som bør vektlegges mer?
d. Opplever du at epleprodusentene og deg selv er inneforstått med IPV/reglementet?
e. Er det noen spesielle retningslinjer/praksiser du som birøkter må forholde deg til?
f. Hva er dine erfaringer knyttet til biehelse, når brukt i pollinering?
g. Merker du noe til klimaendringer i drifta? Hvordan spiller klimatiske forhold inn

C: Consent form

Vil du delta i forskningsprosjektet

"Pollineringstjeneste rettet mot epleproduksjon i Midt-Telemark" ?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke muligheter og hindringer for økt bruk av pollineringstjeneste i epleproduksjon i Telemark. I dette skrivet gir jeg, Birgitte Western (student ved NMBU), deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

I løpet av dette prosjektet skal jeg undersøke dagens forhold rundt pollineringstjenester i Telemark, og finne ut hvilke muligheter /hindringer som er tilstede for å øke pollineringstjenester levert av birøktere til epledyrkere. Ulike prosjekt ser på effekten av mer intensiv pollineringsaktivitet i fruktfelt, og viser til en økt avling ved økt bruk av bikuber i fruktproduksjonen. Det ser ut til å ligge et ubenyttet potensial i å øke pollineringstjenester som næring mot norsk fruktdyrking. Forskningsspørsmål som blir tatt opp for oppgaven er:

- Hva anser norske birøktere som hindringer og muligheter ved å tilby pollineringstjeneste som næring?
- Er det, og i såfall hvordan, forskjell i hvordan eplebønder oppfatter og forstår dagens pollineringstjeneste-situasjon som næring i forhold til birøktere?
- Hva kunne vært potensielle løsninger for å øke omfanget av pollineringstjenester?

Informasjonen som samles fra intervjuer blir analysert og sett i sammenheng med eksisterende teorier og diskutert i masteroppgaven. Masteroppgaven leveres i mai 2020.

Opplysningene og informasjonen gitt til min masteroppgave skal ikke brukes til andre formål (f.eks. undervisning eller andre forskningsprosjekter). Dersom dette endres, vil deltakere bli informert om dette og en eventuelt ny samtykkeavtale vil bli opprettet.

Hvem er ansvarlig for forskningsprosjektet?

Norges miljø- og biovitenskapelige universitet (NMBU) er ansvarlig for prosjektet.
Tor Arvid Breland, professor ved NMBU, er veileder på masteroppgaven.

Hvorfor får du spørsmål om å delta?

Gjennom prosjektets datainnhenting skal jeg intervjue et utvalg av både birøktere (med ulik erfaring innen pollineringstjeneste og utleie) og epledyrkere. Dette for å forstå begge perspektiver av samarbeidet.
Gjennom min jobb i Farmable AS, våren/sommer 2019, kom jeg i kontakt med flere epleprodusenter og har derfor blitt orientert om potensielle eplebønder i Telemark Fylke.

Målet for denne henvendelsen er å nå ut til aktuelle produsenter / birøktere slik at jeg står igjen med et utvalg på totalt 10 intervjuobjekter, helst like mange deltakere i hver utvalgsgruppe. Jeg har valgt å ta kontakt med produsenter / birøktere som faller inn under kriteriene jeg ser etter (aktive i epleproduksjon som hovednæring, holder til i en av satsningsområdene for epleproduksjon i Telemark, har et samarbeidsforhold til birøktere. For birøktere er kriterier i tillegg at de har et potensial for å øke pollinering som en næring i større grad, og er medlem av Norges Birøkterlag).

Telemark er valgt som område for prosjektet ettersom epleproduksjon er et satsningsområde i denne regionen.

Hva innebærer det for deg å delta?

Jeg ønsker å utføre intervjuer, ved bruk av en semi-strukturert intervjuguide. Dersom det godkjennes av intervjuobjekt kan jeg stille spørsmål om å benytte lydopptaker ved siden av. Dette for å forsikre meg om at viktig informasjon ikke uteblir. Utover dette vil det bli tatt notater, av meg selv, under intervjuet.
Hvis du velger å delta i prosjektet, innebærer det at jeg får intervjue deg, noe som vil ta ca. 45 minutter. Intervjuspørsmålene er knyttet til hva slags produksjon du har, omfanget, hva dine tanker er rundt å benytte / leie ut pollineringstjeneste i epleproduksjon, hvilket samarbeidsforhold du har til birøktere/epleprodusenter, og tanker rundt hva som skal til for å øke pollineringstjeneste som næring.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Jeg vil bare bruke opplysningene om deg til formålene fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.
Kun min veileder ved NMBU og meg selv vil ha tilgang til informasjonen oppgitt av deg.
Jeg skal sikre at ingen uvedkommende får tilgang til personopplysningene dine. Navnet og kontaktopplysningene dine vil jeg erstatte med en kode som lagres på egen navneliste adskilt fra øvrige data. Du vil ikke kunne gjenkjennes i publikasjonen.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Prosjektet skal etter planen avsluttes 02.06.2020. Jeg vil sørge for at personopplysninger, opptak og informasjonen blir slettet etter endt prosjekt.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NMBU har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Meg, Birgitte Western, western.birgitte@gmail.com eller 98 47 57 02
- NMBU ved Tor Arvid Breland, tor.arvid.breland@nmbu.no
- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen

Prosjektansvarlig	Eventuelt student
Tor Arvid Breland	Birgitte Western
Signatur	Signatur

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet "Pollineringstjeneste som næring, i epledyrking i Telemark"?, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i intervju, der det også kan være aktuelt å ta det opp med lydopptaker
- ☐ å delta i mulig oppfølgingsintervju, eller telefonsamtale – hvis aktuelt
- ☐ at denne informasjonen kan bli brukt i beskrevet masteroppgave, men ikke linket slik at jeg kan gjenkjennes

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. 02.06.2020

(Signert av prosjektdeltaker, dato)

Norges miljø- og biovitenskapelige universitet
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